

****TITLE****

ASP Conference Series, Vol. ****VOLUME****, ****YEAR OF PUBLICATION****

****NAMES OF EDITORS****

The MAGIC Cherenkov Telescope for gamma ray astronomy

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Abstract. The Major Atmospheric Gamma ray Imaging Cherenkov Telescope (MAGIC) is in commissioning phase and will start to become fully operative by the end of 2003. Located at *El Roque de los Muchachos* in La Palma (Canary Islands, Spain), it has the largest reflector area (17 m diameter) of all the existing Cherenkov telescopes. New technologies have been used to reduce the energy threshold for gamma-ray detection to about 30 GeV. Due to its characteristics, the catalog of very high energy sources will considerably increase with the MAGIC observations, anticipating exciting results for the near future. An overview of the telescope, its current status and first results, together with a highlight of the scientific research is presented.

1. Introduction

Gamma ray astronomy has provided in the last few years spectacular results, led by the success of the CGRO (*Compton Gamma Ray Observatory*) satellite mission which revealed that the high energy Universe was more exciting than expected. During its lifetime, the EGRET telescope onboard the CGRO provided an all-sky survey above 100 MeV consisting of 271 sources (Hartman et al. 1999). Apart of the remarkable detection of 66 AGN Blazars, the vast majority of these sources are still unidentified. Almost during the same period, the ground-based gamma ray astronomy has also been developed. The technique consists of the detection of the atmospheric Cherenkov light emitted by the particle showers initiated by gamma radiation on entering into the atmosphere. This Cherenkov flash lasts for a few ns. The Whipple Cherenkov telescope opened this ground-based era by the detection of the Crab Nebulae in 1989. Then, extragalactic Blazar sources not seen by satellites were also discovered by using this technique. Other instruments based on the same principle have confirmed the Whipple results (HEGRA, CANGAROO, CAT) and nowadays about a dozen gamma ray sources have been detected to emit in the TeV energy range. The observations done by satellites measured well below around 10 GeV, while the existing Cherenkov telescopes have detected sources above 300 GeV. This energy gap, which is still virtually unexplored, is really important to understand which is the origin of the cut-off on the spectra which will explain the lack of sources measured by the Cherenkov telescopes in comparison to EGRET.

The MAGIC (Major Atmospheric Gamma Imaging Cherenkov) telescope was designed in 1998 (Barrio et al. 1998) with the main goal of being the Imaging Atmospheric Cherenkov Telescope (IACT) with the lowest gamma energy threshold possible with the technological improvements affordable and based on the experience acquired with the first generation of Cherenkov telescopes. By using this detection technique, which provides much large effective areas (and much superior flux sensitivity) than satellite detectors, good angular resolution, acceptable energy resolution and a well tested capability to separate gammas from backgrounds, eventually a plethora of new sources will be discovered since for most of known sources the energy spectrum is of power-law nature and therefore they should exhibit a much higher flux in that energy region than at higher energies.



Figure 1. View of the MAGIC Telescope in August 2003. Almost all the mirrors are already on place.

The 17 m diameter $f/D=1$ MAGIC telescope is the largest of the new generation of IACTs. MAGIC is located in the Canarian island of La Palma (28.8 N, 17.9 W) at the *Roque de los Muchachos* observatory (ORM), 2200 m above sea level. Its 241 m² parabolic dish is composed of 964 49.5×49.5 cm² all-aluminum spherical mirror tiles mounted on a lightweight (< 10 ton) carbon fiber frame. The parabolic shape was chosen to minimize the time spread of the Cherenkov light flashes on the camera plane, which allows to reduce the rate of fake events induced by night-sky background light. Mirrors are grouped in panels of three or four, which can be oriented during the telescope operation through a novel active mirror control system to correct for the possible deformations of the telescope structure.

The camera is made of 577 good quantum efficiency, fast photomultipliers with hemispherical photocatode that allows for light double-crossing. Each photomultiplier is coupled to a small light collecting cone to maximize the active surface of the camera. An special wavelength-shifting coating provides red extended sensitivity and allows for light-trapping, which increases the photomultiplier effective quantum efficiency. The total field of view of the camera is of about 4° . The photomultiplier signals are transmitted to a distant Control

House (~ 150 m) by using analog optical fiber signals. Signals are processed by a multilevel trigger system and 300 MHz FADC are used for pulse digitalization.

While all other new generation Cherenkov telescopes aim at the improvement of sensitivity and energy resolution in the 100 GeV regime by using stereoscopic systems of relatively small (10 m) telescopes, MAGIC, through the choice of a single, larger reflector, will achieve the lowest energy threshold among IACTs, of about 30 GeV. Its altazimuth mount can point to anywhere in the sky in about 20 seconds, a unique feature which is essential for the study of transient events like GRBs.

2. The Physics Goals

The main research targets that will be addressed by MAGIC are of a wide nature. They cover subjects as:

- Measurements of the AGNs energy flux above 30 GeV which will allow to determine the gamma ray horizon and eventually extract the cosmological parameters and the extragalactic background light density. Fast flares will be used to constrain Quantum Gravity effects. Multi-wavelength observation campaigns will allow to determine the emission processes that occurs in these sources.
- The systematic study of galactic gamma emitters such as Supernova Remnants, Plerions, X-ray binaries, Pulsars, unidentified EGRET sources, etc. where the observation in this energy range might allow to discriminate between different acceleration mechanisms and might hopefully lead to the identification of the main sources of cosmic rays up to about 10^{15} GeV.
- Due to the MAGIC fast slewing, the observation of Gamma Ray Bursts in the new energy window will be possible.
- Due to its low energy threshold and high sensitivity, MAGIC will be a good instrument for searches of Dark Matter annihilation signals into gamma rays (Flix et al. 2003).

3. The Present Status

The construction of the foundation for the MAGIC telescope started in September 2001 and just few months later the whole telescope structure was completed (December 2001). Mirror installation started in summer 2002 and now of about 200 m² of mirror area are already on place (Figure 1). The Active Mirror Control has proven to be very precise and fast. The telescope drive system was installed during past year and has recently being commissioned up the highest speed which turns out to lead to a maximum repositioning time of 20 seconds. The tracking system has been calibrated using bright star pointings. The camera was installed on the site in November 2002 and has been commissioned in March 2003 after the winter break.

The 1st and 2nd level trigger systems have been already installed and commissioned as well as the whole computing system for the telescope control and

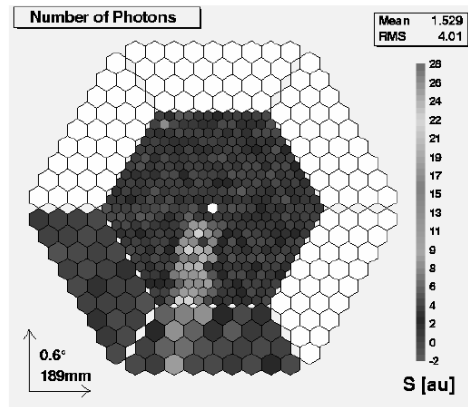


Figure 2. One of the first air showers registered with MAGIC. Not all the outer pixels of the camera were connected to the readout.

DAQ. The installation of the FADC system was completed after some on-place tests and measurements with the whole readout chain have already been performed. Almost all subsystems are integrated into a central control. During June 2003 first Cherenkov images were recorded by using the whole Data Acquisition Chain (Figure 2), as well as light pulses using a novel calibration system, which is being used to characterize the whole telescope.

The construction of a definitive Control House with an unique shape inspired upon the island Dancing-Dwarf traditions has almost reached completion. All the systems are being moved to the Control House, before the official inauguration which will take place on the 10th October 2003. The telescope system are being extensively and intensively checked now and observations of the Crab Nebulae (the standard candle for high energy sources) by this winter will allow us to understand and check the whole detector. We expect to start regular observations by the end of this year 2003.

4. summary

The MAGIC telescope is in its final commissioning phase and it is expected to start regular observations by the end of this year. If the telescope behaves as expected, it will soon be able to provide exciting results on a wide variety of astrophysical phenomena.

Acknowledgments. J. Flix would like to acknowledge all the organizers for the very nice and productive conference.

References

- Barrio J. A. et al. 1998, MPI-PhE-98-5.
- Flix J. et al. in these proceedings.
- Hartman R.C. et al. 1999, ApJS 123, 79.